# Functional flexible adaptation of selective attention in bilingualism

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## 1. Background

Bilingualism modifies the mechanisms of selective attention[1,2]. Here we tested the hypothesis that – instead of increasing attentional capacity[3] – this reflects redistribution of the available finite resources to meet task demands; in line with concepts of functional plasticity and degeneracy[4]. If bilingual modulation of selective attention reflects redistribution rather than enhancement, and the constant demands of bilingualism consume a portion of overall attentional capacity[5], very high attentional loads can be expected to tax bilinguals' performance more strongly than in monolingual controls. To test this, we designed an "extreme" dual attentional task with competing demands. Monolingual and bilingual participants performed an auditory dichotic listening task with varying levels of interference, while also detecting visual targets on the screen. The same task was performed by children and adults, to establish how this adaptation of selective attention in bilingualism might change with maturation.

## 2. Conditions

| | Auditory task | | Visual task |
|---|---|---|---|
| | Attended stream | Interference | |
| 1. Control | None | None | 'Spot the Dog' |
| 2. Single Talker | Story in English | None | 'Spot the Dog' |
| 3. English-English | Story in English | Different story in English | 'Spot the Dog' |
| 4. English-Latin | Story in English | Story in unknown language (Latin) | 'Spot the Dog' |
| 5. English-MuR | Story in English | Acoustic interference (Musical Rain) | 'Spot the Dog' |

## 3. Methods

### Participants

**Study 1: 80 typically-developing children aged 7-12**

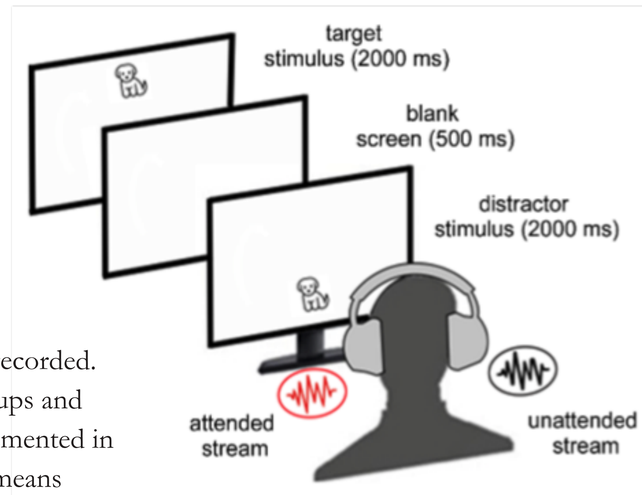
Bilinguals: N=40, mean age 9.7 Monolinguals: N=40, mean age 10.4

**Study 2: 84 adults aged 18-45**

Bilinguals: N=42, mean age 27.4 Monolinguals:N=42, mean age 28.9

**All bilinguals were fully proficient in English and at least one other language.**

**Design** Participants performed auditory and visual tasks simultaneously. In the auditory task they concentrated on a story in English played in one ear, while ignoring a distractor steam presented in the other ear. Distractor stream was manipulated to create 4 levels of interference (Single Talker, Native Language, Unknown Language, or MuR). Each attended story lasted for ~3 min. In the visual task, they pressed the space bar in response to a pre-specified target image (picture of a dog at the top of the screen), but ignored non-target images. The target:non-target ratio was 1:3, with the 24 targets and 72 non-targets presented randomly in each condition.




### Analyses

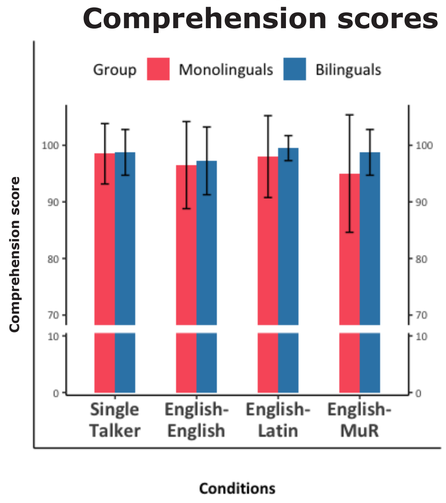
*Auditory task:* After each story, participants completed 10 comprehension questions. Correct answers were scored as 1 and errors as 0, and their probability across groups and conditions was modelled using a glmer function from the binomial family in R (RStudio Team, 2020).

*Visual task:* Reaction times and error rates were recorded. RTs were log transformed and compared across groups and conditions using linear mixed-effect models as implemented in the lme4 R package (Bates et al., 2014), with the emmeans function used for post-hoc comparisons. Significant p-values are reported at $p<.05$.

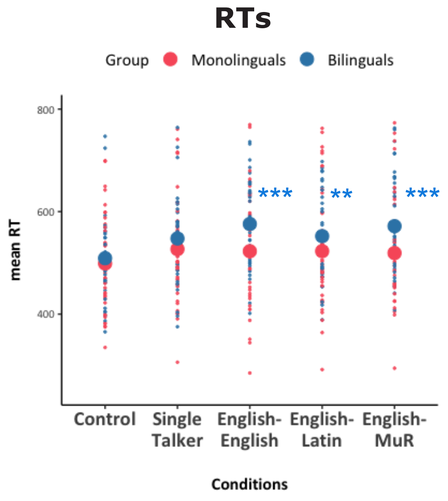
## 4. Results

### Study 1: Children aged 7-12

**Auditory task Comprehension scores**




**Visual task RTs**

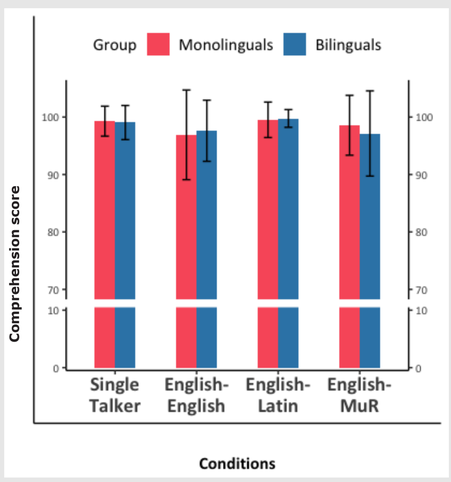



**Auditory task:**
no difference in performance between monolingual and bilingual children

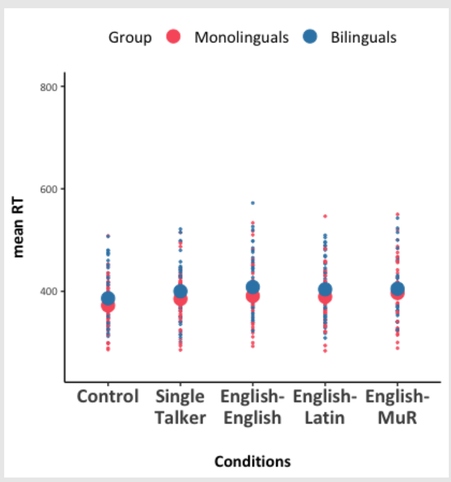
**Visual task:**
slower RTs for bilingual children in conditions of interference (3-5)

### Study 2: Adults aged 18-45

**Auditory task Comprehension scores**




**Visual task RTs**

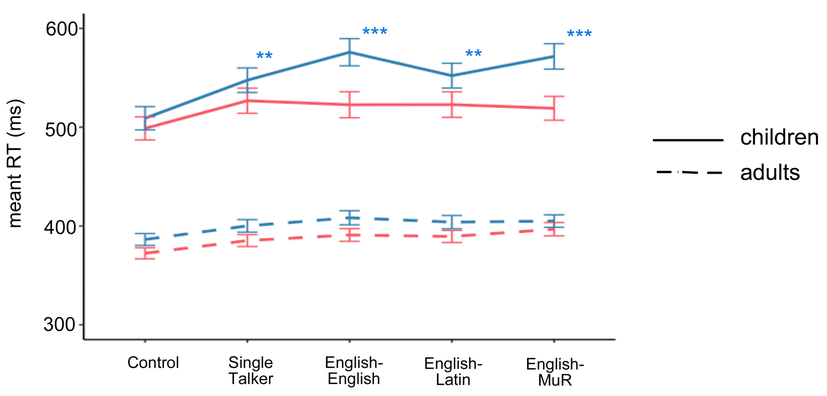



**Auditory task:**
no difference in performance between monolingual and bilingual adults

**Visual task:**
no difference in performance between monolingual and bilingual adults

### Effects of maturation on selective attention performance under high loads

**Children and adults RTs by group and condition**




**Bilingual children disproportionately affected by high attentional loads compared to all other groups**

**Same pattern of responses across conditions in bilingual adults and both monolingual groups**

## 5. Summary

### Auditory task

Equivalent performance on the auditory dichotic listening task for monolinguals and bilinguals in both age groups, with all participants achieving near perfect comprehension scores across all conditions.

### Visual task

A trend for slightly slower responses overall in bilinguals (M = 476 ms across all conditions and age groups for bilinguals, M = 452 ms in monolinguals).

Significantly slower RTs for bilingual children than for monolingual children in conditions of interference.

No significant difference in RTs between monolingual and bilingual adults.

## 6. Conclusions

No evidence for enhanced attentional capacity and superior behavioural performance on tasks requiring attentional control in bilinguals relative to monolinguals.

Instead, data suggest largely equivalent processing in the two groups, with aspects of reduced performance only observed under very high processing load in bilingual children, and with those differences receding in adulthood.

Results consistent with the hypothesis that bilingual adaptation of selective attention reflects the way the increased processing demands of bilingualism interface with the finite attentional capacity, requiring its redistribution and reducing performance when the system is stretched beyond what it can accommodate.

Adaptation to the combined load of second language processing and competing task demands fine-tunes as the selective attention system matures; resulting in optimal selective attention processing in bilinguals even under very high processing loads.

## References

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